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IDENTIFICATION OF INDIVIDUALS BY MEANS OF FINGERPRINTS, PALMPRINTS AND SOLEPRINTS

By G. TYLER MAIRS

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A FINGERPRINT may be defined as an impression from the ridge crests of the friction-skin of the ventral surface of a digit. As the terminal phalange is the only one constantly exhibiting a "pattern" configuration, it is the one utilized for making identification records, although an identification may as accurately be made from an impression of either remaining phalange, or the palm of the hand or the sole of the foot. An impression may be naturally or artificially made. By "naturally" is meant the absence of any transfer medium other than nature's perspiration residuum. A natural print is also sometimes called a "latent" print, because it is often invisible, and, to make a permanent record available for inspection and comparison, it must be visualized and fixed by one of the usual methods. A natural print may be intentionally or unintentionally made.

An artificial impression may be intentionally or unintentionally made, but the medium for recording it is externally applied and is not nature's skin excretions; for example, paint on the hand of a painter; grease on a mechanic's hand; blood on the hand of a butcher; ink on a printer's hand; or the surface is purposely inked as in commercial and institutional spheres. Artificial impressions made with oil, cold cream or other invisible medium must be visualized and fixed as are latent prints.

Mechanically, there are two kinds of fingerprints: *plain* and *rolled*. The *plain* impression is the one used exclusively by the Chinese, by Purkenje, and later by Herschel. This is made by placing the bulb of the finger flat upon the inking surface

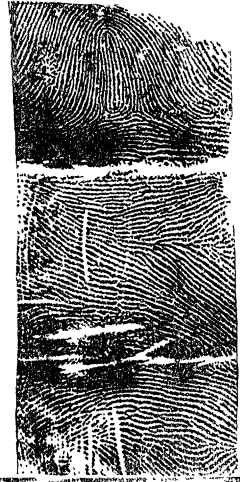


FIG. 1. A rolled digital impression. The apical portion is the "fingerprint" of commerce.

and then upon the receiving surface, the resulting impression being elliptical in shape, the long axis being that of the finger itself. The *rolled* impression is made by placing the digit on the inking surface, radial side in contact, the finger-nail perpendicular to the inking surface, then rolling the bulb of the finger until the ulnar side is in contact and the nail is again perpendicular but reversed in position. The bulb being thus inked, the same operations are repeated on a paper form suitable for recording the impression. This operation produces a cylindrical projection of the ventral surface of the digit which graphically delineates the ridge configuration in all its minutiae.

Thus it will be seen that a friction-skin impression (finger, palm or sole) is a graphical record, by personal contact, of an external physical characteristic capable of being recorded for future reference. It possesses no occult powers of character revelation, but in its gross and minute features is so permanently individual that it is an unerring revealer of personal identity throughout one's lifetime and as long thereafter as the cutis is preserved.

Galton states that:

With regard to the durability of the epidermic ridges they are still present and plainly seen in many Egyptian mummies.

Wilder says that:

In an experiment made by him upon the feet of an infant belonging to the prehistoric cliff dwellers of Southern Utah, where bodies were not even embalmed, but simply dried in the rarefied mountain air, the thenar and apical patterns could be definitely traced after a comparatively simple preliminary treatment.¹

The evolution of the use of the fingerprint and palmprint for personal identification, from the superstitious ceremonial of the ancient Chinese to the refined science of to-day, is, strange to say, a matter of the last sixty years, especially the last thirty years, since Sir Francis Galton placed the fingerprint, and Dr. Harris Hawthorne Wilder, zoologist, placed the palm- and soleprints upon firm scientific foundations. For the Oriental history of their use the reader is referred to Galton's "Finger Prints," Chapter II., and to Mr. Berthold Laufer's "History of the Fingerprint System" (Smithsonian Report, 1912, pp. 631-652). Reading these together, it would seem that the potency of a finger- or palmprint lay more in the ceremonial factor of personal contact necessary in making them, together with the fear of the consequences following a repudiation of a mark so solemnly made, than in any realization of

¹ Dr. H. H. Wilder, "Scientific Palmistry," Pop. Sci. Mo., November, 1902, p. 53.

their inherent individuality. Yet a desire or intent to identify through their use is evident, for their language contained words expressing the act "to identify," also nouns indicating the patterns we call the "whorl," "loop" and "arch."² But such identifications were evidently accomplished by written description in the case of babies in foundling homes,³ and by smudgy and indifferent prints for adults, each verified, evidently without the use of the magnifying lens, as it probably at that early date had no general commercial distribution, if indeed it were known outside of educated and wealthy circles.⁴ Therefore,

² Laufer, Smithsonian Report, 1912, p. 639 and footnote.

³ *Ibid.*, p. 639, ". . . There follows a description of the bodily parts including remarks on the extremities, formation of the skull, crown of the head, birth marks, and design on the fingertips, for later identification. . . . Each Chinese mother is familiar with the finger marks of her newborn." The quality of this "familiarity" may be better imagined after examining the next newborn without a magnifier.

⁴ "Lenses, Their History, Theory and Manufacture," *Optical Journal*, Vol. XIX., May, 1907, page 644, by Mr. J. J. Bausch and Mr. Henry Lomb.

In this historical sketch no indication of Oriental genesis or use is made. The first use of spectacles is placed at about 1285, the invention of d'Armato, of Florence. In Part II., page 728, "Lenses, among the Ancients," they say:

"In point of antiquity lenses as aids to imperfect vision lead all others . . . and still they are comparatively modern, for although we have no authentic records, the consensus of opinion seems to place the invention of spectacles in the thirteenth or fourteenth century. We can say with certainty that the Greeks and Romans of antiquity were unacquainted with glass lenses of long focus, nor do the larger collections in European museums contain any examples, although there have been found in various places convex lenses of short focus made of glass or of rock crystal. There was found in a grave in Nola a plano-convex piece of glass about 4.5 cm. diameter mounted in gold; in Mayence one of 5.5 cm. diameter; a similar one in Pompeii; a bi-convex one in England; finally the oldest lens we have, a plano-convex lens found in Ninevah, of rock crystal. . . . It is remarkable that all these are convex lenses. The fact that lenses have been so seldom found, that the one is mounted in gold, leads to the assumption that they were the rare possessions of wealthy and prominent people. While these lenses were not spectacle lenses in our sense because of their short focus, still we are forced to assume that they were used as burning and magnifying glasses. Passages in Plinius and Seneca show us that the Greeks and Romans were well acquainted with the magnifying power of a globe filled with water, but they ascribed to the water, not to the curved surface, the fact that by means of such an object they could decipher small illegible script. . . . Cicero mentions an 'Iliad' of Homer written on parchment which was comprised in a nutshell. Pliny tells that a Milesian executed in ivory a square figure which a fly covered with its wings. Unless their vision surpassed that of the most skilful modern artists these facts prove that the magnifying power of lenses was known to the Greeks and Romans two thousand years ago."

an identification must have contemplated, in the case of babies at least, only the most superficial resemblance between two "tou" (whorls), or two "ki" (loops), or two "lo" (arches). Of course an arch could be distinguished from a whorl or a loop without a magnifier, but to distinguish between two arches for instance, having a degree of likeness closely approximating identity (see Fig. 10 *a* and *b*), the absence of the magnifier would certainly preclude any such accurate discrimination as is absolutely necessary to-day. Aside from the prints themselves, this absence of any realization of and reliance upon the individuality of the friction-skin configuration seems clearly shown by Rashiduddin, the famous Persian historian, who wrote in 1303 as follows (extract from "Cathay," by H. Yule, Vol. III., p. 123) :

Extracted from the Historical Cyclopedia of Rashiduddin. . . .

Lastly, the business arrives at the sixth board, which is called Siushtah. All ambassadors and foreign merchants when arriving and departing have to present themselves at this office, which is the one which issues orders in council and passports. . . .

When matters have passed these six boards, they are remitted to the Council of State, or Sing, where they are discussed, and the decision is issued after being verified by the Khat Angusht or "finger-signature" of all who have a right to a voice in the Council. This "finger-signature" indicates that the act, to which it is attached in attestation, has been discussed and definitely approved by those whose mark has thus been put upon it.

It is *usual* in Cathay, when any contract is entered into, for the outline of the fingers of the parties to be traced upon the document. For experience shows that no two individuals have fingers precisely alike. The hand of the contracting party is set upon the back of the paper containing the deed, and *lines are then traced around his fingers up to the knuckles* in order that if ever one of them should deny his obligation this *tracing* may be compared with his fingers and he may thus be convicted.

Here the fingerprint is not even suggested, but a sort of ceremonial is used involving the five fingers, the desired psychic effect being accomplished by very formally tracing lines "around his fingers up to the knuckles," evidently such as the children of to-day trace in playing the game of *tit-tat-toe*. To us, this is a most crude method of identification, but it must have worked or it would not have been "usual," for the psychology of fear was doubtless as potent then as now, although perhaps not so clearly understood. At any rate, this ancient use of fingerprints, finger-outlines and handprints has none but historical interest for us. Nothing of any scientific value has as yet come down to us by virtue of its own worth or momentum as it were, *e. g.*, the silk worm and silk. Galton observes (1897) :

No account has yet reached me of trials in any of their courts of law about disputed signatures, in which the identity of the party who was said to have signed with his fingerprint had been established or disproved by comparing it with a print made by him then and there.

Fifteen years later (1912) Mr. Laufer observes:

Indeed, it is striking that we do not find in any author a clear description of it and its application. The physicians in their exposition of the anatomy of the human body do not allude to it, and it is certain that it was not anatomical or medical studies which called it into existence. It formed part of the domain of folklore, but not of scholarly erudition.

In this connection Mr. Laufer makes (p. 645) an interesting citation from A. H. Smith's "Proverbs and Common Sayings from the Chinese," thus:

The Chinese, like the Gypsies and many other peoples, tell fortunes by the lines upon the inside of the fingers. The circular striæ upon the finger tips are called "*tau*," a peck; while those which are curved, without forming a circle, are styled "*ki*," being supposed to resemble a dust pan. Hence the following saying:

"One peck, poor; two pecks, rich; three pecks, four pecks, open a pawnshop; five pecks, be a go-between; six pecks, be a thief; seven pecks, meet calamities; eight pecks, eat chaff; nine pecks and one dust pan, no work to do—eat till you are old."

How different the contributory beginnings of the present-day scientific identification! It was *a physician* in his exposition of the anatomy of the human body who first called attention to the friction-ridge patterns—"M. Malpighi, 1686 A.D., quoted by Alix, 1867, and by Schlaginhaufen, 1905."⁵ Again, in 1823, another physician, J. E. Purkenje, in a now famous thesis, partially translated by Galton, went still farther and described and classified the various ridge configurations as shown by "plain" impressions.⁶ The late Sir William J. Herschel makes an additional citation from this thesis which is interesting; he says:

Referring to "the varieties of the tonsils, and especially of the papillæ of the tongue, in different individuals" (no mention of fingers) he finishes his sentence and his essay by saying: "From all of which (varieties) sound materials will be furnished for that *individual knowledge of the man* which is of no less importance than a general knowledge of him is, especially in the practise of medicine." Herschel adds: "No part of his essay conveys an inkling of identification by means of any of the individual varieties on which he always lays stress, not even his pioneer work in the classification of the markings on fingers."⁷

⁵ Wilder, "Bibliography of Friction-skin Configuration," *Biological Bulletin*, Vol. XXX., No. 2, page 249.

⁶ Galton, "Finger Prints," pp. 85-88 and plate.

⁷ Herschel, "The Origin of Finger Printing," p. 35 (1916).

Concerning the labors of the late Sir William J. Herschel in the application of the idea of friction-skin identification, Sir Francis Galton, writing at a time when the facts considered were a matter of Galton's personal knowledge, states his conclusions thus:

If the use of fingerprints ever becomes of general importance, Sir William Herschel must be regarded as the first who devised a feasible method for regular use, and afterward officially adopted it.⁸

No allusion is made to the "discovery"⁹ of their use by Herschel, the emphasis being on "the first to devise a feasible method for their regular use." Galton had already cited their prior use in his introductory chapter, saying:

The second chapter treats of the previous employment of fingerprints among the various nations, which has been almost wholly confined to making daubs, without paying any regard to the delicate lineations with which this book alone is concerned. Their object was partly superstitious and partly ceremonial: superstitious, so far as a personal contact between the finger and the document was supposed to be of mysterious efficacy; ceremonial, as a formal act whose due performance in the presence of others could be attested.¹⁰

Again in Chapter II.,

Though mere smudges, they serve in a slight degree to individualize the signer. . . . The ridges dealt with in this book could not be seen at all in such rude prints, much less could they be utilized as strictly distinctive features.¹¹

Read in connection with Galton's conclusions, Herschel's "Origin of Finger Printing" tells us how the idea of this as a "feasible method" developed in his mind, and gives the evolution of the method "for regular use." "There was nothing very original about that, as an idea," says Herschel, concerning his taking of Konai's handprint.¹² The change of method came quickly, but the idea of judicial sanction after "many years." Herschel says:

Trials with my own fingers soon showed me the advantage of using them instead of the whole hand for the purpose then in view, *i. e.*, for securing a signature which the writer [maker] would obviously hesitate to

⁸ Galton, "Finger Prints," Ch. II., p. 28.

⁹ Herschel, "The Origin of Finger Printing," page 32. Here Herschel claims only the "discovery of the *value* of finger prints."

¹⁰ Galton, introductory chapter, page 3.

¹¹ Galton, Ch. II., p. 23. Also Laufer's "History," Plate 3, showing two thumb smudges on a Tibetan promissory note. The print on Plate I., recorded as late as A.D. 1839, is reasonably clear. Its clearness may have been intentional.

¹² Herschel, "Origin of Finger Printing," page 8.

disown. [The old idea of fear again utilized.] That he might be infallibly convicted of perjury if he did, is a very different matter. That was not settled, and could not have been settled, to the satisfaction of courts of justice, till, after many years, abundant agreement had been reached among ordinary people [jurors?]. The very possibility of such a "sanction" to the use of a fingerprint did not dawn upon me till after long experience, and even then it became no more than a personal conviction for many years more.¹³

The researches of Sir Francis Galton were begun in 1880.¹⁴ Their results were epochal. Pre-Galtonian prints were exclusively the "plain" impressions of to-day, amply sufficient for identification, but not for that precise classification so necessary for the modern Fingerprint Record File. Galton's introduction of the "rolled" impression or cylindrical projection of the finger; the utilization of the "minute triangular plot" or delta (Wilder's tri-radius) found in all rolled impressions (except that of the arch) as "corner stones" of his classification system; the substitution for a single "plain" impression of a complete series of ten rolled impressions, with plain impressions of the fingers as a check on printing the rolled impressions in proper sequence; together with his researches concerning the individual persistence of the ridge configuration (the results of which have been accepted as proof of persistency) made possible the present-day scientific systems of fingerprint identification. His conclusions on persistency have been amply confirmed by the late Sir William J. Herschel's series of impressions from two of his own fingers, the first taken in 1859, at the age of twenty-six years; the second, in 1877, and the third, in 1916, at the age of eighty-three years, a total interval of fifty-seven years, and, as he remarks:

For length of persistence they can not at present be matched.¹⁵

As Herschel gave of the fruits of his labors to Galton, so, in turn, Galton gave to Sir Edward Richard Henry, G. C. V. O., Commissioner of Police of the Metropolis, London, England. Sir Henry says:

In the system here described, many of his (Galton's) terms have been adopted, definitions accepted and suggestions followed whenever practicable.¹⁶

Upon this Galtonian foundation Sir Henry built the present

¹³ Herschel, "Origin of Finger Printing," page 9.

¹⁴ Galton, "Finger Prints," Ch. I., page 2.

¹⁵ Herschel, "The Origin of Finger Printing," page 30.

¹⁶ Henry, "The Classification and Uses of Finger Prints," 1913, page 5.

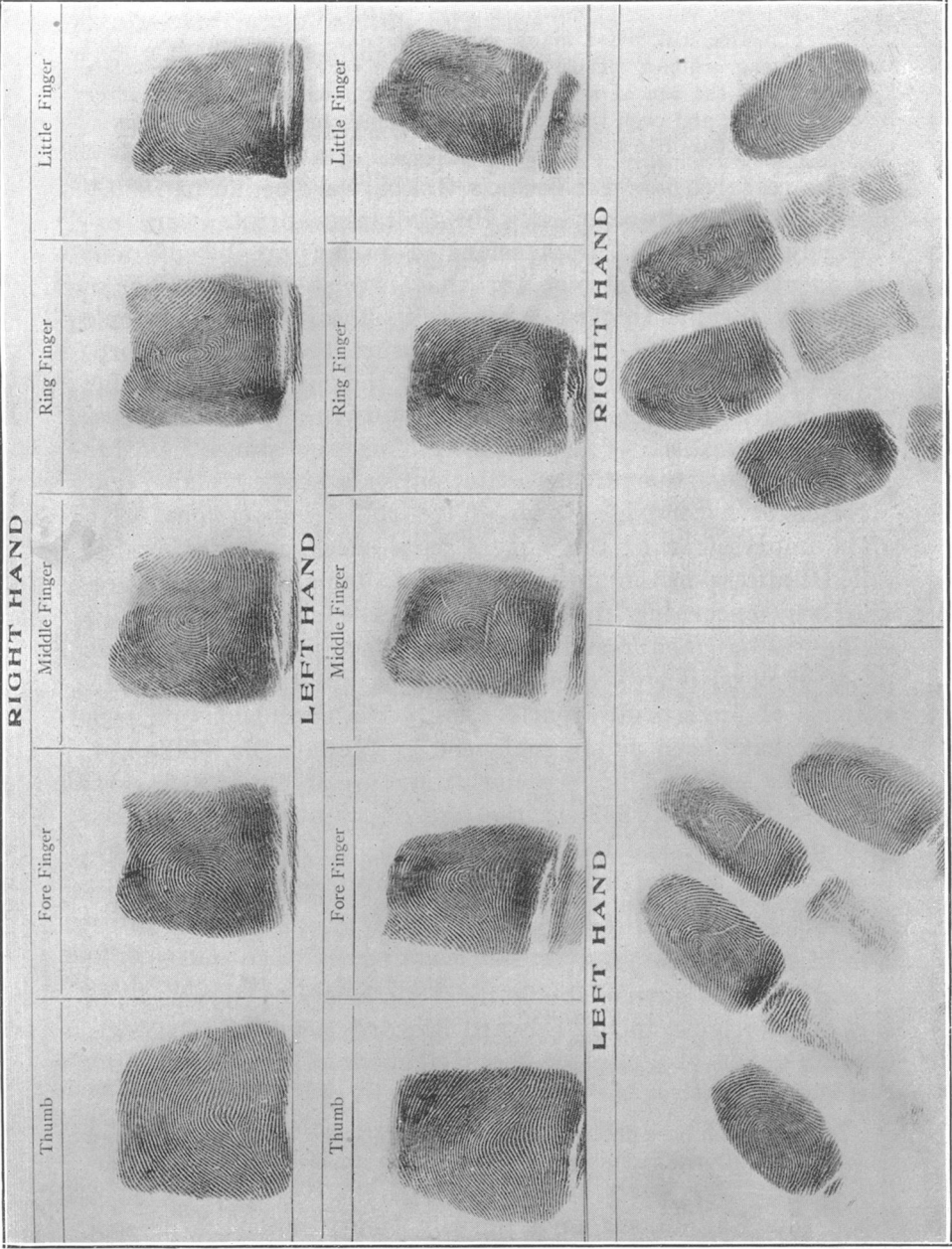


FIG. 2. A series of ten apical dermatographs (fingerprints) taken in conformity with the Henry System of Finger Print Classification.

extensively used Henry System of Finger Print Classification, which enables one familiar with its intricacies to make a set of ten apical impressions or dermatographs, classify it, and produce the person's history record (assuming one on file) in a period of time varying from five to fifteen minutes. Under this scientific system nothing is required of the subject save the set of ten apical dermatographs. Given this and nothing more, no name, no address, no physical description or photograph, the identifier "solves for x," to use an algebraic term. A record being produced, the subject's medical history, for instance, in the case of a hospital or clinic for the feeble-minded or insane, is at once available, no matter how long the interval between treatments, or the changed facial appearance of the subject, or similarity in names.

Galton in his "Finger Prints," Chapter IV, page 57, says concerning the ridges covering the palm of the hand and the sole of the foot:

Having given but little attention to them myself they will not be again referred to.

Opposite, on Plate III., Fig. 6, are displayed four palm outlines and one showing the general configuration on both palm and fingers.

In this field of investigation Galton's mantle fell on one of his American correspondents (also a correspondent of Bertillon) who has confined himself to the palms and soles, and of whom it may fairly be said, to paraphrase Galton: If the use of palm- and soleprints ever becomes of general importance, Dr. Harris Hawthorne Wilder, zoologist, must be regarded as the first who devised a feasible method for their regular use and afterward promulgated it. In one of his first papers on the subject Dr. Wilder says:

The great individual variation of these parts in the human being is not without significance and furnishes an excellent illustration of the *biological truth that the perfection and constancy of an organ are directly proportional to its necessity in the life of the organism . . .* that only useful and important parts retain a certain normal form in the various individuals of a given species, and that, as they become of less importance, they tend more and more to *vary individually*, the range of variation increasing with time and the degree of uselessness, if such an expression may be allowed; conversely, an organ that is seen to possess marked individual variation is shown to be of secondary importance, and may be either a rudimentary organ, that is one on the way towards a greater usefulness in the future and in which the variations represent the numerous experiments or attempts to find the form best adapted for a special purpose, or, again, it may be a vestigial organ, or one in which its point of usefulness

is passed and in which the variations represent various degrees of degeneracy, or stages in its gradual eradication from the organism.¹⁷

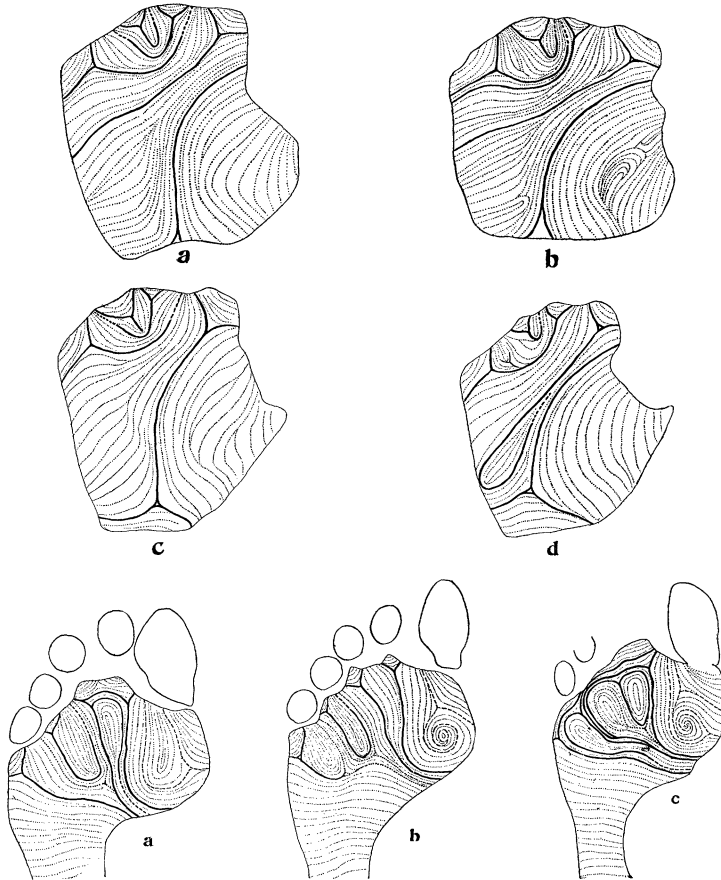


FIG. 3. Tracings from four left palms and three left soles, showing the great individual variation. (From H. H. Wilder's "Palm and Sole Impressions," *POPULAR SCIENCE MONTHLY*, Sept., 1903.)

In a subsequent paper almost a year later, in which the subject is dealt with in more detail, he says:

These ridges and their peculiar disposal are an inheritance from our arboreal ancestors, and appear to be formed in the oldest primates by the coalescence of single units which arrange themselves in rows.¹⁸ Whether

¹⁷ Wilder, "Scientific Palmistry," *POPULAR SCIENCE MONTHLY*, November, 1902, pp. 46-47.

¹⁸ Wilder, "Palm and Sole Impressions," *POPULAR SCIENCE MONTHLY*, Sept., 1903, p. 396. In a footnote Dr. Wilder says "This and other morphological points of which I shall make use in this article are from an unpublished paper on the morphology of the subject by an associate in my department, Miss Inez L. Whipple. At my suggestion Miss Whipple has

or not this phylogenetic or racial stage is now passed through in each human embryo in accordance with the law of biogenesis has not as yet been shown, but it is certain that the ridges are seen fully formed and in their adult condition in a four-months' embryo, and that no change can afterward take place in any detail.

As these surfaces are thus *individually variant* and as their condition is *absolutely permanent through life*, they offer the best criteria for a system of individual records, especially since they may be so easily recorded by means of printed impressions. All these points have been shown by Mr. Galton, who has taken as a basis for his system the markings that cover the balls of the fingers, his "finger tips." The present paper considers the remainder of the ridged surfaces and is thus seen to be *an extension of the Galtonian system to new territory*. Whether ultimately the universal personal records which will surely become necessary in the near future will be based upon a part or the whole of these surfaces is of no real moment, and it is with the idea of being of genuine assistance to Mr. Galton, and without any attempt at rivalry, that I offer in the following pages a method of recording identity by means of palms and soles.¹⁹

In a subsequent paper, entitled "Palm and Sole Studies," published in *The Biological Bulletin* (Vol. XXX., Feb., 1916, page 135), the subject is introduced as follows:

In the study of the details of the configuration of the friction ridges found covering the surfaces of the human palms and soles there opens up a field of the greatest value to the biologist. *Varying greatly individually*; still following the lines laid down for them in more primitive mammals, yet modified and varied as the result of mechanical causes; showing markedly and with certainty a direct inheritance from the immediate parents as well as from generations more remote; they may be used with great profit by the morphologist, the ethnologist, or the student of genetics, while, as the surest and most positive characters of an individual, they may serve the authorities in the identification of a human body, living or dead.

Undoubtedly the patterns are complicated, and many new conceptions, and the new terminology which expresses them, confront the beginner, as in any new field; but this much once accomplished, there opens up to the investigator an almost endless series of new phenomena the study of which in the few years during which the subject has received special attention has been no more than begun.

Continuing, this paper considers such subjects as "A Primitive Palm Print"; the "Heritability of Friction-skin Characters"; Palm and Sole Markings in both duplicate and fraternal twins, also conjoined twins or those which have never separated completely.

The morphological investigations by Miss Inez L. Whipple undertaken the comparison of the human conditions of palm and sole with those of the lower primates and other mammals, and has studied also the ontogenetic development of the parts in man and other forms. This work is of the greatest value in the present connection and will be published in full in a short time."

¹⁹ Wilder, "Palm and Sole Impressions," page 396.

(now Mrs. H. H. Wilder), previously referred to, were eventually published (in English) in a foreign scientific publication²⁰ under the title given below. This paper has proved to be "the fundamental paper on the comparative morphology of the ridge patterns of the palms and soles, and includes the study of the relief of the ridge surfaces in all mammals, and the growth of the ridge surfaces as modified by this. This paper with that of Schlaginhaufen, 1905, are of first importance in the scientific study of human friction ridges."²¹ It is certainly most unfortunate that such a fundamental work as this is to the professional fingerprint identifier should be practically unavailable owing to the fact that it was snapped up by a foreign scientific publisher.

A satisfactory digest of this treatise is almost out of the question as every section and paragraph is essential. Space will permit for no more than the table of contents, to show its broad scope and exhaustive treatment; and a few extracts from the text concerning the ridges and apical ridge patterns in man:

THE VENTRAL SURFACE OF THE MAMMALIAN *CHIRIDUM*,
WITH SPECIAL REFERENCE TO THE CONDITIONS
FOUND IN MAN.

By MISS INEZ L. WHIPPLE

With Preface

By PROFESSOR HARRIS HAWTHORNE WILDER, PH.D.

Department of Zoology, Smith College, Northampton, Mass.

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²⁰ *Zeitschrift für Morphologie und Anthropologie*, Stuttgart, Bd. VII., pp. 261-368 (107 pages), 1904.

²¹ Wilder, "Bibliography of Friction-skin Configuration," *Biological Bulletin*, Vol. XXX., p. 251.

PART III. Epidermic Ridge Patterns in Prosimians and Primates.

- A. Preliminary classification.
- B. Typical primary patterns.
- C. Modified primary patterns.
- D. Secondary and false patterns.

The process of ridge formation and their distribution with relation to the pads is exhaustively treated in Part II., Sec. B. After devoting fourteen pages to the careful examination of ridge formation in the lower mammals, in which the develop-



FIG. 4a.

FIG. 4b.

FIG. 4. Dermatographs from the human heel (left, female) showing in *a*, a normal condition, the unit elements being mostly all fused into ridges, only a few one, two and three unit ridges being present; in *b*, the opposite condition is shown, it being difficult to find a ridge of more than four or five units, the single elements having never fused into ridges. (From H. H. Wilder's collection, Nos. 722 and 754 respectively.)

ment is traced from the simplest epidermic structure, the scale or wart, the most common form of which is a single sweat gland and its pore opening near the middle of the structure (The "island" or "unit ridge" of the identifier); and the fusion of these elements by one of three observed methods to form the ridge (Fig. 4 *a*, *b*); and demonstrating that the concentric whorl is the primary pattern, Miss Whipple says regarding the ridge development in the higher primates and man:

Although in the higher primates the complete covering of the surface of the chirodium by ridges seemed at first to preclude the possibility of obtaining any evidence of the method of ridge formation, the fact that in

lower forms the transition stages from simple epidermic structures such as warts and rings to fully formed ridges occurs in the regions which are less exposed to pressure, suggested the possibility of finding in the narrow transition area between the ridged region and the skin of the dorsum, especially in embryos, some suggestion as to this process. As the elevation of the ridges is due largely to the rather late development of the stratum corneum, it was difficult to find a stage which was sufficiently advanced to render the ridges distinguishable externally and which would at the same time show the simpler epidermic structures. An advanced human fetus

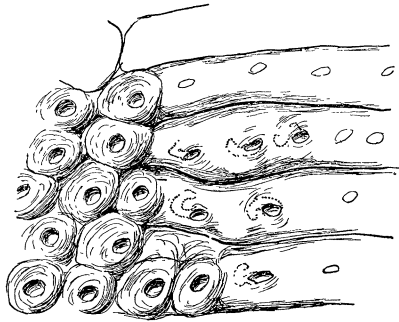


FIG. 5.

proved the most satisfactory for this purpose, and the best results were obtained from the transition region along the sides of the middle phalanges. Fig. 5 shows a camera drawing of a surface preparation of the epidermis of this region. Upon the side of the digit the orifices of the sweat glands are wide and each is surrounded by an elevated rim of the stratum corneum, the whole structure being that of an epidermic wart. These warts appear, however, to be arranged in rows, and the drawing shows a rapid transition from separate warts to ridges, one feature of this transition being the increased length of the coiled ducts of the sweat glands and a lateral compression of their orifices. Except that the transition is a narrow one, the process of ridge formation differs in no particular from that of *Midas lagothrix*. Moreover these warts having been demonstrated in the embryo, it seems safe to conclude that the little separate elevations continuing for a short distance the course of the ridges in the transition regions of the adult skin, usually particularly well seen upon the inner side of the terminal phalanx of the second finger (Fig. 6a), are actually primitive warts, examination with a lens demonstrating the opening of a sweat gland in the center of each. In some cases these warts seem to be grouped or fused into rings suggesting the conditions in *Didelphys* and *Lemur*; usually, however, they occur singly. The very frequent occurrence of "islands" in the primate friction-skin also suggests the development of ridges phylogenetically from separate components (Fig. 6b).

Three monkey embryos, one an *Alouatta*, the other two Platyrrhine forms (species undetermined), showed along the edge of the friction-skin similar transition stages from warts to ridges.

Concerning the function of the epidermic ridges (Part II.,

Sec. D), after extended observations and discussion, the investigator says:

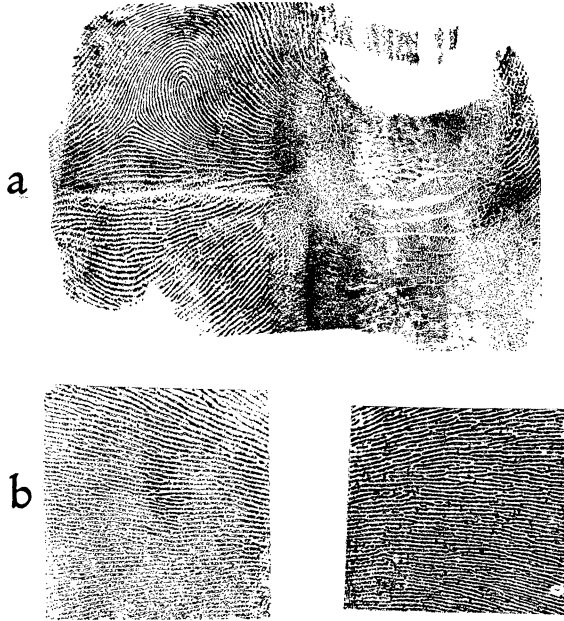


FIG. 6.

The general principles, then, which are involved in the function of ridges are:

1. That the function is primarily to increase resistance between contact surfaces for the purpose of preventing slipping, whether in walking or in prehension.

2. The direction of ridges is at right angles with the force that tends to produce slipping, or to the resultant of such forces when these forces vary in direction.

3. The shape of the pad elevation, the direction of flexion, and the direction of motion are the factors determining the direction of the slipping force, and therefore the direction of the ridges.

Again, "Incidentally the ridges acquire an important tactile function."

In Part III., Sec. C, is discussed Modified Primary Patterns; the various types of modification, and their probable cause,

although in doing so it must be borne in mind that a single type of pad modification seldom occurs unaccompanied by others. We may consider these types, however, to be four in number:

1. Failure of divergents, resulting in triradii becoming extra-limal or obliterated. (See Fig. 7*a* and *b*.)

2. Reduction of pads, resulting in degeneration of triradii.

3. Flattening of pads, resulting in a deviation from the concentric arrangement of ridges upon the pad area.

4. Fusion of pads, resulting in the coalescence and in the exclusion of triradii.



FIG. 7. Two apical graphs in which (a) one triradius has become extralimal, and the other nearly so; in (b) both triradii have become obliterated. In each case an "accessory degeneration triradius" has developed in connection with a loop formation. At the extreme lower corners unit ridge elements may be seen.

Continuing, and referring to group (2), Miss Whipple says:

The modification of patterns which are due to pad reduction are probably the most frequent of all pattern modifications. As reduction has pro-

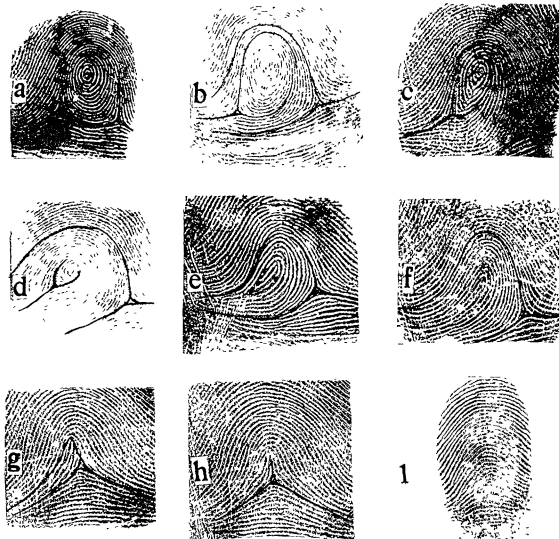


FIG. 8.

ceeded farther in man than in most monkeys (excepting the Anthropoids) *we may select from different individuals of the human species cases which illustrate every step in the process.* The series given in Fig. 8 show how, in the apical pads, beginning with the slipping of one or both of the embracing radiants of one triradius within those of the other, a variation involving at first only a few ridges (b), one triradius may approach

nearer and nearer to the center of the pattern (*c, d, e*), its radiants embracing fewer and fewer concentric ridges until the triradius finally suffers complete degeneration, leaving the pattern known in Galton's terminology as the "loop" (*f*) which has only one triradius, the loop opening in the direction of the divergent of the triradius which has degenerated. Again, by a similar *series of minute variations*, this remaining triradius may approach more nearly to the middle of the pattern, until the loop involves but a single ridge, from which condition it is only a step through Galton's "tented arch" to the "simple arch" in which the last vestige of the second triradius has disappeared. These transition forms in the apical patterns were fully recognized and described by Galton as constituting a slight obstacle to a perfectly systematic classification of fingerprints. . . . It should also be noted that there may occur a simultaneous approach of both triradii to the center of the pattern, the pattern remaining typical in form but reduced in size.

This type of modification is then traced in palms and soles. Under group (3),

Types of pattern modification which are due to a flattening of the pad, a condition which is in some instances correlated with reduction, and in others with extension of the pad area. With the change of pressure upon a pad naturally accompanying such a change of form, very decided modifications in the disposition of ridges occur leading in the direction of the establishment of parallel straight ridges, such as we would expect to find upon a flat surface. The flattened, reduced apical pads both of man and of a few of the monkeys were found to illustrate one very common method of attaining this end. It will be seen from the series shown in Fig. 9 that



FIG. 9.

this line of variation may begin by the displacement of only a few ridges at the center of the pattern, the result being the establishment of a spiral rather than a perfectly concentric pattern. Following this may come a greater and greater amount of variation from the concentric arrangement until a double loop (vortex duplicatus of Purkinje) or even an S-shaped figure is formed. In rare cases more often seen in the apical patterns of the human foot and in the proximal patterns this line of variation has proceeded so far that the pattern has become separated into distinct loops and an accessory degeneration triradius is introduced (see Fig. 7*a* and *b*), that is a triradius not originally present in the typical scheme but formed incidentally in the process of degeneration of the pattern.

Modifications from this same cause occurring in the palms and soles are then considered at considerable length and in great detail.

From this brief biological review it will be seen that any friction-skin impression or dermatograph is really much more than a record of merely external epidermic characteristics, for these features are in turn conditioned upon internal tissue structure of the dermis, the configuration of which is determined and fixed during early embryonic life, and is therefore capable of being associated with but a single individual. Except for a change of size proportional to the growth of the bodily parts, or changes acquired during postembryonic life by external causes such as deep cuts or burns, or from disease of the tissue evidenced by a felon, boil, etc., the configuration remains unchanged through the individual's life.

What then is required to establish an identification; what is the process; how do these biological or anatomical conditions satisfy the requirements?

For guidance, let us consult an authority²² on the principles of identity evidence:

. . . In the process of identification of two supposed objects, by a common mark, the force of the inference depends on the *degree of necessariness of association of that mark with a single object*.

For simplicity's sake the evidential circumstance may thus be spoken of as "*a mark*." But in practise it rarely occurs that the evidential mark is a *single* circumstance. The evidencing feature is usually a group of circumstances, which as a whole constitute a feature capable of being associated with a single object. Rarely can one circumstance alone be so inherently peculiar to a single object. It is by adding circumstance to circumstance we obtain a composite feature or mark which as a whole can not be supposed to be associated with more than a single object. The process of constructing an inference of identification thus consists usually in adding together a number of circumstances, each of which by itself might be a feature of many objects, but all of which together can conceivably coexist in a single object only. Each additional circumstance reduces the chances of there being more than one object so associated.

Continuing, he says, in discussing the terms identity, alike, similar, and resemblance:

We remember to have read in a judgment of the Indian High Courts (unfortunately we can not now give the reference) that the judges considered the case was not proved because the evidence only established *likeness* and not identity. . . . terms such as "exact likeness," "precise similarity" are misleading. For as soon as you have removed all internal difference and resemblance is carried to such a point that perceptible [material] difference ceases, then you have identity. As soon as you begin to analyze resemblance you get something else than it; and when you argue from resemblance, what you use is not the resemblance, but the point of resemblance, and a point of resemblance is clearly an identity.²³

²² John H. Wigmore, "Principles of Judicial Proof, General Principle of Identity Evidence."

²³ "Principles of Judicial Proof," John H. Wigmore, Little, Brown & Co., Boston, Mass., 1913, pages 64-67.

Conceiving a fingerprint, or any friction-skin impression, as “a mark,” what is the “degree of necessariness of association” of that mark with the particular individual whose dermatograph it is?

Dr. Wilder has stated for us the biological truth that the perfection and constancy of an organ are directly proportional to its necessity in the life of the organism; that only useful and important parts retain a certain normal form in the various individuals of a given species, and that as they become of less importance they tend more and more to *vary individually*. Mrs. Wilder has traced this degeneration of mammalian pads and the consequent individual variations in their friction-skin configuration, and has shown us that it has progressed farther in man than in most other mammals, so far, “that we may select from different individuals of the human species cases which illustrate every step in the process.” We have seen that *this process is composed of a series of minute variations, constant in the individual*, but progressive and variable among mammals as a whole; and that in the individual the ridges are the result of the coalescence of simple tissue structures and are formed and their configuration fixed in a four-months’ embryo.

Since it is inconceivable that these minute dermal structures should themselves be identical or coalesce identically in any two instances, the inevitable conclusion seems to be that the “degree of necessariness of association” of this graphic mark with the individual is *absolute*; that even the possibility of the same or different individuals, having on any two parts of the friction-skin areas identical ridge configurations, is *nil*. Any dermatograph or impression of the friction-skin configuration is therefore a graphic record, by personal contact, of inherent anatomical or dermal characteristics, exclusively individual in the person possessing them, and constant through his life.

But as Professor Wigmore points out, an “evidential mark” usually consists of a group of circumstances, each of which by itself might be a feature of many objects, but all of which together can conceivably coexist in but a single object only; and that the process of constructing an inference of identification consists in “adding circumstance to circumstance.”

Analyzed, any friction-skin impression, or more specifically, any *apical dermatograph*, may be thought of as the record of a group of anatomical or dermal circumstances, called by Galton “ridge characteristics.” In its gross features it may repre-

sent any of the stages of progressive mammalian variation as shown by Mrs. Wilder and grouped by Sir Edward Henry, on the basis of certain gross likenesses, as whorls, accidentals, twin-loops, lateral-pocket loops, central-pocket loops, ulnar loops, radial loops, tented arches, and the simple arch, the ultimate stage of degeneration. It therefore follows that these "marks" or types of configuration may well be a feature of many objects or fingers (in fact we find them so);²⁴ so that the repetition of an impression of the same type only raises a suspicion that the two graphs may be from the same digit (or friction-skin area). Aided by a good magnifying glass, a careful comparison of each anatomical circumstance or ridge characteristic, its form and relative position in the configuration, of both dermatographs is therefore necessary. For, if the impressions be *not* from the same digit (or friction-skin area), the record of material anatomical circumstances necessarily associated with the individual in question (*e. g.*, Fig.

²⁴ For the mathematics of this variability of types the reader is referred to a fifty-seven-page article on the "Association of Finger Prints," by H. Waite, M.A., B.Sc., in *Biometrika* (Vol. X., No. 4, May, 1915), pages 421-478. In addition to the text there are over one hundred statistical tables, enough to satisfy the most ravenous "figure shark." On pages 432-433, Mr. Waite says: "It is convenient at this stage to summarize a few of the most important points which have been brought to light in the foregoing pages. These are: (a) A greater divergence of types in the right hand than in the left. (b) A clustering of the same type in the hands of an individual. (c) The uneven distribution of the various types in the different fingers, especially the almost entire absence of radial loops except in the index. (d) The differentiation of types in the two hands, in particular the large excess of whorls in the right hand and of arches in the left thumb. (e) Where there is any significant difference in the means, standard deviations and coefficients of variation in the numbers of the ridges in the loops of the two hands those quantities are always greater for the right hand than for the left. (f) The relationship between digits of the same name on opposite hands is closer than that between any others which are more widely separated. The relationship between the thumb and any other digit is less close than that of any pair not including the thumb."

"We may thus conclude that the left hand in its distribution of patterns is differentiated from the right and that the individual fingers are associated in a differential way with special types. We know that the right hand is differentiated from the left in use, and it would seem reasonable to suppose, even if we can not account for the adaptation to use, that the fingerprints have been differentiated in accordance with this use differentiation. It may be suggested that the fingerprints, if differentiated in accordance with diversity of use of the several fingers and of each hand, follow a law of differentiated utility, and not as the bones a law of maximum general utility of the finger."

10 *a*) will be absent from the graphs alleged to be his (Fig. 10 *b* and 10 *d*), and it will be found impossible to locate any minute dermal circumstances or characteristics identical to both configurations, the graphs being considered merely alike or similar, according as the resemblance is near or remote.

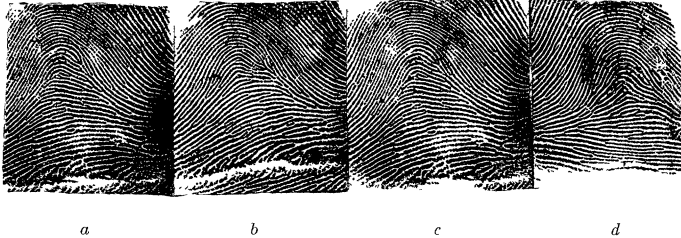


FIG. 10. Four rolled apical dermatographs: *a* is from the right middle finger, *b* from the right forefinger, and *c* an additional graph from the middle finger of the same hand; *d* is from a different individual. Note that even graphs *a* and *c* are not between themselves identical, but only alike; no material differences occurring in their common contact areas, the identity of the individual is unerringly inferred and established by adding dermal circumstance to circumstance.

But, if the dermatographs be from the same digit (or friction-skin area) the record of anatomical circumstances necessarily associated with the individual (Fig. 10 *a*) will be found in the common contact area of the graph truly his (Fig. 10 *c*). It will, therefore, be possible by comparing both configurations to add dermal circumstance to circumstance and to carry the resemblance to such a point that material difference ceases in the common contact areas, and from them to a common cause, the individual digit; for all the minute dermal circumstances taken together (in these two graphs nearly 100 pairs) can conceivably coexist in but a single finger; and the finger conceivably belong to but a single individual.